

Cephalopod assemblages caught by trawling along the Southern Tyrrhenian Sea (Central Mediterranean)

Asociaciones de cefalópodos capturados por la pesca de arrastre comercial en el Tirreno meridional (Mediterráneo central)

Daniela GIORDANO*, Teresa BOTTARI* and Paola RINELLI*

Recibido el 26-II-2004. Aceptado el 27-IX-2004

ABSTRACT

The teuthofauna assemblages of the Southern Tyrrhenian Sea are identified utilising data from five trawl surveys. A total of 139 hauls were carried out in late spring or the middle of summer between 1995 and 1999, and 25 cephalopod species were found between 18 and 652 m of depth. The assemblages were analysed with the Bray-Curtis similarity index. Depth showed a positive correlation with cephalopod distribution. Four main cephalopod groups were defined: inshore (10-100 m), shelf (101-200 m), slope (201-600 m) and midslope (350-600 m). *Loligo media* was the main species for the first group, *Illex coindetii* for the second, *Todaropsis eblanae* for the third group and *Todarodes sagittatus* for the last group.

RESUMEN

Se identifican las asociaciones de teutofauna capturadas por los arrastreros comerciales en el Tirreno meridional. Se analiza la fauna de cefalópodos recogida en 139 lances realizados en primavera o mediados del verano durante cinco campañas de pesca de arrastre realizadas entre 1995 y 1999. Se identificaron 25 especies de cefalópodos capturadas entre 18 y 652 m de profundidad. El análisis de las asociaciones faunísticas se realizó mediante el índice de similitud de Bray-Curtis. La profundidad tiene una correlación positiva con la distribución de los cefalópodos, pudiéndose definir cuatro grupos principales: costero o litoral (10-100 m), de la plataforma (101-200 m), del talud (201-600 m) y del talud medio (350-600 m). *Loligo media* fue la principal especie del primer grupo, *Illex coindetii* del segundo, *Todaropsis eblanae* del tercero, y *Todarodes sagittatus* del último grupo.

KEY WORDS: Biogeography, cephalopods, trawl fishery, Tyrrhenian Sea, faunal assemblages, Mediterranean Sea.
PALABRAS CLAVE: Biogeografía, cefalópodos, pesquería de arrastre, asociación faunística, Mar Tirreno, Mediterráneo.

INTRODUCTION

The geographic and bathymetric distributions of demersal cephalopods have been studied in detail in different Mediterranean areas: Western Mediterranean Sea (SARTOR, BELCARI, CARBONELL, GONZÁLEZ,

QUETGLAS AND SÁNCHEZ, 1998; SORIANO, SÁNCHEZ LIZASO AND GUERRA, 2003; VILLANUEVA, 1995); the coasts of Libya and Tunisia (BONNET, 1973); Marmara Sea (KATAGAN, SALMAN AND BENLI, 1993;

* Istituto per l'Ambiente Marino Costiero IAMC-CNR, Messina Section, Spianata San Raineri 86, 98122 Messina, Italy. Corresponding author: Daniela Giordano. E-mail: daniela.giordano@iamc.cnr.it

UNSAI, UNSAI, ERK AND KABASAKAL, 1999); Eastern Mediterranean Sea (RUBY AND KNUDSEN, 1972; KNUDSEN, 1981; SALMAN, KATAGAN AND BOLETZKY, 1999); Ligurian Sea (RELINI, DE ROSSI, PIANO AND ZAMBONI, 2002; BERTULETTI AND ORSI RELINI, 1986; ORSI RELINI AND BERTULETTI, 1989; WURTZ, 1979; ORSI RELINI, 1995); Sardinian Sea (BONNET, 1965; CUCCU, ADDIS, DAMELE AND MANFRIN PICCINETTI, 2003); Tyrrhenian Sea (BERDAR, POTOSCHI, CAVALLARO, CAVALIERE AND LI GRECI, 1983; BERDAR AND CAVALLARO, 1975; LUMARE 1968, 1970; BELCARI, BIAGI, BIAGI, DE RANIERI, MORI AND PELLEGRINI, 1986; MANNINI AND VOLPI, 1989; BELCARI AND SARTOR, 1993; BELCARI, SARTOR AND DE RANIERI, 1998; WURTZ, MATRICARDI AND BELCARI, 1992; SPEDICATO, MINETTI, REBORA, MATRICARDI AND WURTZ, 1990; GIORDANO AND PERDICHIZZI, 1998; BELLO AND ARCULEO, 1994; GIORDANO AND CARBONARA, 1999); Sicilian Channel (JEREB AND RAGONESE, 1991, 1994; RAGONESE, JEREB AND DI STEFANO, 1992); Adriatic Sea (BELLO AND MOTOLESE, 1983; GUESCINI AND PICCINETTI MANFRIN, 1986; GAMULINBRIDA AND ILIJANIC, 1972; CASALI, MANFRIN PICCINETTI AND SORO, 1998; BELLO, 1990; PASTORELLI, VACCARELLA AND DE ZIO, 1995); Ionian Sea (PANETTA, D'ONGHIA, TURSİ AND CECERE, 1986; TURSİ AND D'ONGHIA, 1992; D'ONGHIA, MATARESE, TURSİ, MAIORANO AND PANETTA, 1995); Catalan Sea (MANGOLD-WIRZ, 1963; SÁNCHEZ, BELCARI AND SARTOR, 1998); and Aegean Sea (D'ONGHIA *ET AL.*, 1995; SALMAN, KATAGAN AND BENLI, 2002).

In particular, assemblages of cephalopod communities have been studied in different areas of this basin (UNGARO, MARANO, MARSAN, MARTINO, MARZANO, STRIPPOLI AND VLORA, 1999; TSERPES, PERISTERAKI, POTAMIAS AND TSIMENIDES, 1999; GONZÁLEZ AND SÁNCHEZ, 2002; QUETGLAS, CARBONELL AND SÁNCHEZ, 2000). Information about spatio-temporal distributions of these species and their linkage to environmental factors is necessary for the study of many commercial species. The studies focused on demersal assemblages and in particular on their persistence, such as the capability to maintain

the same specific composition during a lag time are useful even for management purposes (BIAGI, SARTOR, ARDIZZONE, BELCARI, BELLUSCIO AND SERENA, 2002).

In this respect, this work analyses the structure of cephalopod assemblages, providing information concerning their distribution for all four groups defined: inshore, shelf, slope and mid-slope.

MATERIAL AND METHODS

The study area is situated in the Southern part of the Tyrrhenian Sea (central Mediterranean) between Suvero Cape (Calabria) and San Vito Cape (Sicily). The data here reported come from five trawl surveys carried out from 1995 to 1999, during the MEDITS project (International bottom trawl survey in the Mediterranean Sea). The experimental surveys were always conducted during late spring or the middle of summer. Hauls were carried out from one hour before dawn until one hour after sunset. A fishing vessel equipped with an experimental trawl net with 20 mm stretched mesh size in the cod-end, and 2-2.5 m of vertical opening (FIORENTINI, COSIMI, SALA, LEONORI AND PALOMBO, 1999) was used. A total of 139 hauls were carried out, randomly allocated into five bathymetrical strata: "A": 10-50 m; "B": 51-100 m; "C": 101-200 m; "D": 201-500 m; "E": 501-800 m (BERTRAND, GIL DE SOLA, PAPACONSTANTINOU, RELINI AND SOUPLÉ, 2002).

The duration of each haul was 30 minutes at depths less than 200 m and one hour at greater depths. All the data were standardised to one hour haul duration. All cephalopods were identified and counted on board. A multivariate approach, on the basis of the calculation of a triangular similarity matrix (group-average linkage), by depth, year and abundance (number of specimens/hour), according to BRAY AND CURTIS (1957), with relative dendrogram and non metric plan Multi Dimensional Scaling (MDS) was elaborated (CLARKE

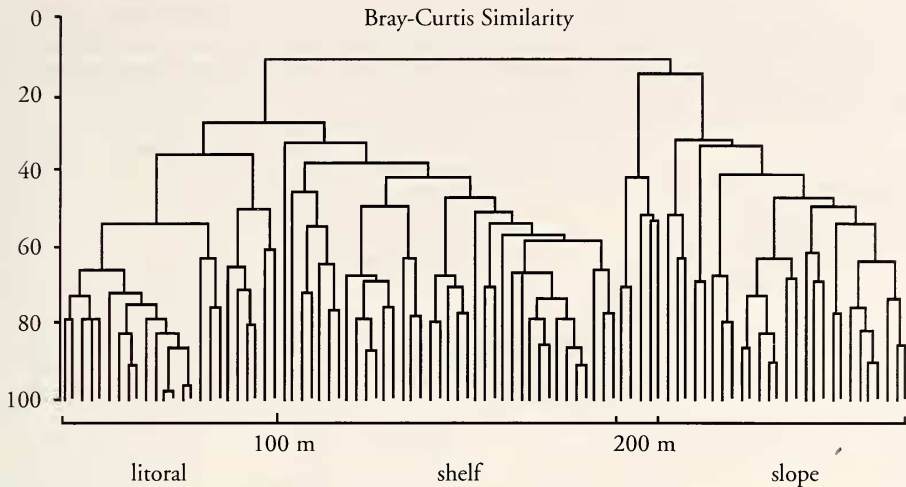


Figure 1. Dendrogram showing similarities between hauls for the 1996 surveys. Mean depth of each haul is presented.

Figura 1. Dendrograma que muestra las similitudes entre los arrastres de 1996. Se indica la profundidad media de cada arrastre.

AND WARWICK, 1994). Because the annual variations of cephalopod distribution were not significant, the five surveys were pooled together to calculate the total cluster. Hauls in which only one species was caught and the species with abundance values lower than 3 were not considered for the analysis. To establish which taxa contributed most to the separation of one group from another, the SIMPER routine was used (CLARKE, 1993). Abundance values were also analysed by means of univariate indices, in relation to the four assemblages evidenced by cluster analysis: total number of taxa (S), total number of individuals (N), richness of Margalef (d), Shannon-Wiener diversity (H') and Pielou's evenness (J) indices. The cumulative abundances were illustrated in order of dominance as K -dominance curves.

RESULTS

Twenty-five species of cephalopods were collected belonging to three orders and eight families. In Table I the systematic list of species, drawn up according

to BELLO (1986), within the bathymetrical range of each species, is reported. In particular, *Onychoteuthis banksii*, *Ancistroteuthis lichtensteinii* and *Abralia veranyi* were caught only once during the period studied.

The cephalopods collected were distributed between 18 and 652 m of depth. The more coastal species was represented by *Sepia officinalis*, confined within the depth of 68 m. Fifty percent of the species showed a wide bathymetrical range that included the shelf and the beginning of the slope. The widest distribution was shown by *Eledone cirrhosa* (72-584 m), *Scaevargus unicolorrhus* (38-549 m), *Todaropsis eblanae* (61-613 m) and *Pteroctopus tetracirrhus* (118-633 m). *Alloteuthis subulata*, *Octopus vulgaris* and *Eledone moschata* were found only on the continental shelf. On the contrary, *Octopus salutii* and *Rossia macrosoma* were caught at over 200 m of depth. *Histioteuthis bonnellii* was found exclusively in the deepest stratum.

The dendrogram of all surveys (Fig. 1) showed three principal clusters: I, inshore (<100 m); II, shelf (80 - 200 m) and III, slope (200 - 600 m). The coastal group was characterized by *Loligo media*

Table I. Cephalopod species captured from 1995 to 1999 off the Southern Tyrrhenian Sea, showing their depth range and mean depth of occurrence with the associated standard deviation (SD).

Tabla I. Especies de cefalópodos capturadas desde 1995 a 1999 en el mar Tirreno meridional, indicando su rango de distribución batimétrica, profundidad media y la desviación estándar asociada (SD).

	Min	Max	Media	SD
Class CEPHALOPODA Cuvier, 1798				
Subclass COLEOIDEA Bather, 1888				
Order SEPIOIDEA Naef, 1916				
Family Sepiidae Leach, 1817				
Genus <i>Sepia</i> Linnaeus, 1758				
<i>Sepia officinalis</i> Linnaeus, 1758	40	68	49.5	12.66
<i>Sepia orbignyana</i> Férussac in Orbigny, 1826	61	432	185.5	96.87
<i>Sepia elegans</i> Blainville, 1827	40	345	137.3	74.02
Family Sepiolidae Leach, 1817				
Subfamily Sepiolinae Leach, 1817				
Genus <i>Sepiola</i> Leach, 1817				
<i>Sepiola rondeletii</i> Leach, 1817	110	395	276	115
Genus <i>Rondeletiola</i> Naef, 1921				
<i>Rondeletiola minor</i> (Naef, 1912)	117	297	207	127.28
Subfamily Rossiinae Appellof, 1898				
Genus <i>Rossia</i> Owen in Ross, 1835				
<i>Rossia macrosoma</i> (Delle Chiaie, 1830)	277	596	484.5	115.56
Genus <i>Neorossia</i> Boletzky, 1971				
<i>Neorossia caroli</i> (Joubin, 1902)	123	608	309	195.9
Order TEUTHOIDEA Naef, 1916				
Suborder MYOPSIDA Orbygn in Férussac & Orbigny, 1840				
Family Loliginidae Lesueur, 1821				
Genus <i>Loligo</i> Lamarck, 1798				
<i>Loligo vulgaris</i> Lamarck, 1798	18	294	75.72	72
<i>Loligo forbesi</i> Steenstrup, 1856	72	505	134.2	127.3
<i>Loligo media</i> (Linnaeus, 1758)	18	383	99.1	75.43
Genus <i>Alloteuthis</i> Wulker, 1920				
<i>Alloteuthis subulata</i> (Lamarck, 1798)	76	143	109.5	47.4
Suborder OEGOPSIDA Orbigny, 1845				
Family Enopteuthidae Pfeffer, 1900				
Subfamily Enopteuthinae Pfeffer, 1900				
Genus <i>Abralia</i> Gray, 1849				
<i>Abralia veranyi</i> (Ruppell, 1844)	316	316	-	-
Family Onychoteuthidae Gray, 1847				
Genus <i>Onychoteuthis</i> Lichtenstein, 1818				
<i>Onychoteuthis banksii</i> (Leach, 1817)	358	358	-	-
Genus <i>Ancistroteuthis</i> Gray, 1849				
<i>Ancistroteuthis lichtensteinii</i> (Férussac, 1839)	562	562	-	-
Family Histiototeuthidae Verrill, 1881				
Genus <i>Histiototeuthis</i> Orbigny, 1840				
<i>Histiototeuthis bonnellii</i> (Férussac, 1834)	531	645	565.5	53.33
<i>Histiototeuthis reversa</i> (Verrill, 1880)	383	652	565.3	89.4
Family Ommastrephidae Steenstrup, 1857				
Subfamily Illicinae Posselt, 1890				
Genus <i>Illex</i> Steenstrup, 1880				
<i>Illex coindetii</i> (Verany, 1839)	60	593	213.7	128.7

Table I. Continuación.
 Tabla I. Continuation.

	Min	Max	Media	SD
Genus <i>Todaropsis</i> Girard, 1890				
<i>Todaropsis eblanae</i> (Ball, 1841)	61	613	323.1	152.2
Subfamily <i>Todarodinae</i> Adam, 1960				
Genus <i>Todarodes</i> Steenstrup, 1880				
<i>Todarodes sagittatus</i> (Lamarck, 1798)	114	593	438.5	154.69
Order OCTOPODA Leach, 1818				
Suborder INCIRRATA Grimpe, 1916				
Family Octopodidae Orbigny in Férussac & Orbigny, 1840				
Subfamily Octopodinae Orbigny in Férussac & Orbigny, 1840				
Genus <i>Octopus</i> Cuvier, 1798				
<i>Octopus vulgaris</i> Cuvier, 1798	27	114	62.86	25.85
<i>Octopus salutii</i> Vérany, 1836	295	432	374	70.87
Genus <i>Scaevurgus</i> Troschel, 1857				
<i>Scaevurgus unicolor</i> (Delle Chiaje in Férussac & Orbigny, 1840)	38	549	174.1	110.8
Genus <i>Pteroctopus</i> P. Fischer, 1882				
<i>Pteroctopus tetracirrus</i> (Delle Chiaje, 1830)	118	633	353.8	147.83
Subfamily Eledoninae Grimpe, 1921				
Genus <i>Eledone</i> Leach, 1817				
<i>Eledone moschata</i> (Lamarck, 1798)	18	143	115.4	92.82
<i>Eledone cirrhosa</i> (Lamarck, 1798)	72	584	200.4	119.87

and *Loligo vulgaris*. In the shelf group (Table IIa) *Illex coindetii* and *Loligo media* prevailed, followed by *Sepia orbignyana*, *Sepia elegans* and *Scaevurgus unicolor*. The slope group (Table IIb) was characterized by *Todaropsis eblanae*. The Multi-dimensional Scaling analysis (30%: Stress 0.15) also showed four groups, well discriminated by depth (Fig. 2). There is also a midslope group (Fig. 3), limited to a few hauls, in which *Todarodes sagittatus* was the prevalent species.

Analysing the univariate indices (Table III), elaborated for the four groups, the highest biodiversity was observed in the shelf. In this macrostratum, the highest values of Margalef and Shannon-Wiener indices were recorded as well as the highest number of species and individuals. The highest values of H' found at this bathymetrical level can be explained by the relative homogeneity in abundance of the most frequent species.

However, a trend was observed according to the depth as evidenced also by the cumulative abundance curve, in which the shelf group showed the highest biodiversity and the midslope the lowest. In this last group in fact both d and H' values recorded the lowest values (0.973 and 1.063, respectively).

Finally the Evenness (J') values ranged from 0.616 to 0.661. The higher value was recorded for the last cluster. Also in the second cluster this value is quite high.

DISCUSSION AND CONCLUSIONS

The 25 cephalopod species distributed in 8 families recorded in this study account for 42.4% of species reported from the Mediterranean (MANGOLD AND BOLETZKY, 1988; GUERRA, 1992). Absent were certain species of the Sepiolidae family and pelagic species. In compari-

Table IIa. Indicator species and related data from the SIMPER analysis. Abbreviations: AA, average abundance, contribution of each species in each group; AT, average term, average Bray-Curtis contribution of each species to distinguish between groups. The ratio (AT/SD), the percentage contribution to the separation (%), and the cumulative percentage (Cum %) are shown for each group comparison.

Tabla IIa. Especies indicadoras y datos relacionados, según el análisis SIMPER. Abreviaturas: AA, abundancia promedio, contribución de cada especie en cada uno de los grupos; Average Term (AT), contribución promedio de Bray-Curtis de cada especie en la diferenciación de los grupos. Cada grupo viene definido, además, por la relación AT/SD (ratio), la contribución porcentual (%), y el porcentaje acumulativo de cada especie (Cum %).

Average dissimilarity: 84.1	inshore AA	shelf AA	AT	Ratio	%	Cum (%)
<i>I. vulgaris</i>	106.88	0.90	34.64	1.39	41.18	41.18
<i>I. coindetii</i>	0.58	26.62	0.50	0.67	13.74	54.92
<i>L. vulgaris</i>	18.88	0.02	0.47	1.03	13.22	68.13
<i>S. elegans</i>	0.05	0.41	0.28	0.71	7.70	75.83
<i>S. orbignyana</i>	0.00	8.86	5.69	0.53	6.77	82.6
<i>S. unicirrhus</i>	0.00	0.29	0.21	0.6	5.45	88.05
<i>E. cirrhosa</i>	0.05	0.13	0.13	0.6	3.57	91.62
Average dissimilarity: 99	inshore AA	shelf AA	AT	Ratio	%	Cum (%)
<i>L. media</i>	106.88	0.00	47.82	1.48	48.3	48.3
<i>L. vulgaris</i>	18.88	0.00	0.80	1.07	19.25	67.56
<i>T. eblanae</i>	0.00	0.46	9.70	0.64	9.8	77.35
<i>P. tetracirrhus</i>	0.00	2.74	3.81	0.67	3.85	81.2
<i>O. vulgaris</i>	0.09	0.00	0.13	0.63	3.17	84.37
<i>S. orbignyana</i>	0.00	2.89	2.68	0.32	2.71	87.08
<i>I. coindetii</i>	0.04	1.67	2.43	0.56	2.46	89.54
<i>E. moschata</i>	2.00	0.19	2.37	0.76	2.39	91.93
Average dissimilarity: 92.7	inshore AA	shelf AA	AT	Ratio	%	Cum (%)
<i>L. media</i>	21.43	0.00	19.36	1.03	20.89	20.89
<i>I. coindetii</i>	26.62	1.67	17.55	0.82	18.94	39.83
<i>S. elegans</i>	9.57	0.00	10.85	0.82	11.71	51.54
<i>S. orbignyana</i>	8.86	2.89	10.51	0.69	11.34	62.88
<i>T. eblanae</i>	1.14	10.56	9.67	0.70	10.43	73.31
<i>S. unicirrhus</i>	6.54	0.85	7.77	0.69	8.38	81.69
<i>E. cirrhosa</i>	3.30	0.67	4.95	0.63	5.34	87.04
<i>P. tetracirrhus</i>	0.22	2.74	3.47	0.83	3.75	90.79

son, TURSÍ AND D'ONGHIA (1992) caught 24 species of cephalopods in the Ionian Sea, D'ONGHIA ET AL. (1995) 29 species in the North Aegean Sea, QUETGLAS ET AL. (2000) found 30 species in the Balearic Sea, SÁNCHEZ ET AL. (1998) found 36 species in the northern Tyrrhenian Sea and 47 in the Catalan Sea and SORIANO ET AL. (2003) found 18 species in the upper continental slope of Alicante (western Mediterranean).

In previous surveys of the study area before 1995 (GIORDANO AND PERDICHIZZI, 1998), 32 species of cephalopods were identified. In general, a similar cephalopod distribution pattern was observed from 1994-1995 trawl surveys, but the sampling was carried out at a different period (in autumn) and with a different net (with 36 mm of stretched mesh). The species caught in the previous faunistic list in the same area were: *Sepioloa affinis*,

Table IIb.
Tabla IIb.

Average dissimilarity: 100	inshore AA	midslope AA	AT	Ratio	%	Cum (%)
<i>L. media</i>	106.88	0	50.79	1.52	50.79	50.79
<i>L. vulgaris</i>	18.88	0	21.3	1.08	21.3	72.09
<i>T. sagittatus</i>	0	7	9.23	0.85	9.23	81.32
<i>O. vulgaris</i>	2.5	0	3.63	0.62	3.63	84.94
<i>S. orbignyana</i>	0	3.6	3.51	0.42	3.51	88.46
<i>E. moschata</i>	2	0	2.61	0.74	2.61	91.07
Average dissimilarity: 97.18	inshore AA	midslope AA	AT	Ratio	%	Cum (%)
<i>L. media</i>	21.43	0	20.96	1.05	21.57	21.57
<i>I. coindetii</i>	26.62	0	18.87	0.81	19.42	40.98
<i>S. elegans</i>	9.57	0	11.87	0.84	12.21	53.19
<i>S. orbignyana</i>	8.86	3.6	11.6	0.72	11.93	65.13
<i>T. sagittatus</i>	0.16	7	8.66	0.99	8.91	74.04
<i>S. unicirrhus</i>	6.54	0.2	8.41	0.68	8.66	82.7
<i>E. cirrhosa</i>	3.3	0	5.64	0.61	5.8	88.5
<i>E. moschata</i>	0.22	0	2.65	0.64	2.72	91.22
Average dissimilarity: 92.38	inshore AA	midslope AA	AT	Ratio	%	Cum (%)
<i>T. eblanae</i>	10.56	0	23.25	0.95	25.17	25.17
<i>T. sagittatus</i>	0.3	7	21.55	1.3	23.33	48.5
<i>P. tetracirrhus</i>	2.81	0.4	11.48	0.96	12.42	60.92
<i>S. orbignyana</i>	2.22	3.6	10.36	0.57	11.21	72.14
<i>R. macrosoma</i>	0.19	1	6.78	0.6	7.34	79.48
<i>I. coindetii</i>	1.67	0	5.67	0.6	6.14	85.61
<i>S. unicirrhus</i>	0.85	0.2	3.49	0.57	3.78	89.39
<i>E. cirrhosa</i>	0.67	0	2.93	0.46	3.17	92.56

Sepiolo ligulata, *Sepiolo robusta*, *Sepietta oweniana*, *Sepietta neglecta* (Sepiolidae), *Chroteuthis veranii* (Chroteutidae) and *Bathypolypus sponsalis* (Octopodidae). On-board observation of catches indicated that the demersal fauna sampled is strongly influenced by depth. The

depth range of each species with mean depth and standard deviation are reported in Table I. *Eledone cirrhosa* (32-584 m), *Scaevurgus unicirrhus* (38-549 m), *Todaropsis eblanae* (61-613 m), *Sepia elegans* (40-432 m), *Loligo media* (18-383 m) and *Illex coindetii* (60-593 m) showed

Table III. Univariate diversity indexes for each cluster. Abbreviations: S, number of species; N, number of specimens; d, richness of Margalef; J', Pielou's evenness; H', Shannon-Wiener diversity. *Tabla III. Índices univariados de diversidad de cada grupo. Abreviaturas: S, número de especies; N, número de ejemplares; d, riqueza según Margalef; J', uniformidad según Pielou; H', diversidad de Shannon-Wiener.*

Cluster	S	N	d	J'	H'
inshore	8	709	1.066	0.616	1.28
shelf	15	2267	1.812	0.652	1.765
slope	12	529	1.754	0.619	1.539
midslope	5	61	0.973	0.661	1.063

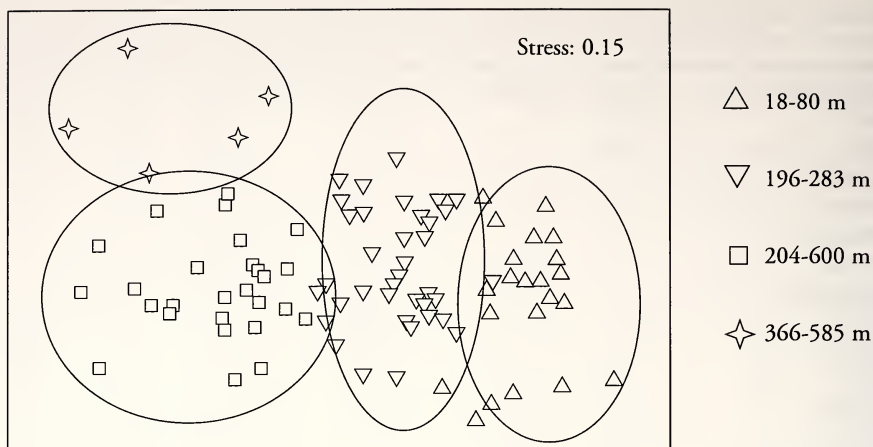


Figure 2. Multidimensional scaling ordination analysis for the five surveys.
 Figura 2. Análisis de ordenación de escalamiento multidimensional para las cinco campañas.

a wide distribution range, extending up to the continental slope.

During the present study four main cephalopod groups were defined: inshore (10-100 m), shelf (101-200 m), slope (201-600 m) and midslope (350-600 m). *Loligo media* was the main species for the first group, *Illex coindetii* for the second, *Todaropsis eblanae* for the

third group and *Todarodes sagittatus* for the last group.

ACKNOWLEDGEMENTS

We are grateful to Dr. Patrizia Jereb for helpful comments on the manuscript.

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